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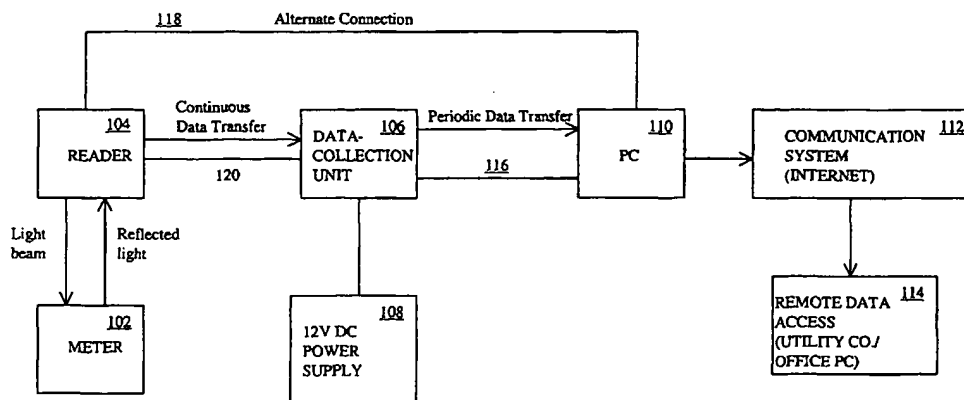
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(54) Title: **A METHOD AND APPARATUS FOR READING AND CONTROLLING ELECTRIC POWER CONSUMPTION**



(57) Abstract: An electro-optical, automatic meter reader for enabling a consumer to view and manage power consumption through a browser. A sensor attached to a bracket is mounted to the outside cover of a utility meter without modification of the meter or removal of its housing. A data-collector stores data obtained from the sensor via a serial port which may also provide power for the sensor, thus avoiding use of a dedicated power supply. The data-collector connects to a computer which provides a centralized object through which to view and manage power consumption. The real-time and combined historic data can be used to forecast whether usage will fall above or below a predetermined usage level at the end of a given period of time. In response to a forecast exceeding the level, the computer displays the appropriate graph in a red colored bar within a quantity vs. time chart. The computer may control power consuming devices. A communication system may be established to the system for remote management by the consumer or by the utility company for its own billing and management purposes.

A METHOD AND APPARATUS FOR READING AND CONTROLLING ELECTRIC POWER CONSUMPTION

Field of the Invention

5 This invention relates generally to a utility usage measurement system, and more particularly to a means of obtaining real-time utility consumption readings and also managing utility consumption by controlling end-use devices from the computer or personal digital assistant (PDA) of the consumer.

Background of the Invention

10 There are various types of automatic meter reading devices (AMR) which use optical light-sensing arrangements to provide remote utility readings for determining utility consumption and for billing purposes. These devices were typically developed as a cost-effective alternative to the existing meter reading methods and devices. For example, these AMR devices avoid having a person walk or drive from establishment to establishment and manually read each meter. However, the majority of methods using optical light-sensing devices are installed inside the existing meter and/or require professional installation. Thus, a skilled or trained individual must physically remove the glass housing present on such meter in order to install the automatic reading device. This process is inefficient and also very costly for either the utility company or the consumer.

15 In U.S. Pat. No. 5,767,790, the device utilizes a photoelectric sensor for reading the watt-hour indicator of electricity service usage. A light source beams a light on a rotating disk in the meter. The disk reflects the light except for one darkened area, which absorbs the beam of light. The reflected light is sensed by the photoelectric sensor and a pulse is sent each time the reflected light is not sensed. Each pulse indicates one full

Description

[0001] This invention generally relates to facilities management systems and more particularly to an integrated and networked system for facilities management systems which is remotely operable through Internet protocols.

[0002] Buildings, campuses, multi-location environments, and other types of facilities commonly use monitoring and control systems to manage the operational disciplines of environmental systems, electrical and power distribution systems, security systems, and health/safety and fire protection systems.

[0003] Pertinent to an understanding of facilities management systems, is the understanding that there are many commercially available products which are able to provide sensing and control functions necessary for effective facilities management. These products generally range from very expensive, elaborate systems, to rather simple systems having relatively low intelligence. Originally, facilities management systems depended on linking remote pieces of facilities equipment to a centrally located command and control console by dedicated serial cabling or some other non-network connection. Defining a facilities management architecture in terms of dedicated cabling suffers from a number of logical flaws and disadvantages.

[0004] In particular, geographically diverse or remote facilities, even those located on a common campus, could not be managed effectively because of the difficulty attendant to making robust connections between and among facilities equipment and between the facilities equipment and a client/server system over geographical distances in excess of 30 meters. Moreover, managing even the facilities equipment disposed throughout a single facility from a remote central management console is highly disadvantageous in that such remote management contemplates a dial-up connection made between the central console and a supported piece of equipment in order to effect the management and control function. Such dial-up connections are slow, have limited functionality and exhibit poor control response because of the inherent time-lapse attendant between an event requiring remediation and the appropriate response.

[0005] In addition to the difficulties attendant to non-network interconnects, facilities equipment manufactured by different vendors could not be linked together in a single communication structure because each brand of equipment typically employed a different transmission protocol and/or proprietary communication connection from other brands. Thus, an HVAC installation by Johnson Controls Company would be unable to be coupled to the same communication structure as an HVAC installation from Liebert Corporation.

[0006] Notwithstanding the difficulties inherent in attempting to link together multi-vendor equipment into a facility, significant difficulties are encountered when at-

tempting to link together equipment designed to accommodate different disciplines, even though manufactured by the same vendor. Linking different types of equipment together is often impossible due to the inherently different nature of the tasks undertaken by devices designed for the environmental, electrical, security and fire protection disciplines. Such multi-task linking often precluded an effective facilities communication structure even when multi-vendor and multi-location issues were avoided.

[0007] Several attempts have been made in the prior art to improve communications with any facilities management system by devising various means for linking together different brands of equipment in a multi-vendor architecture. The primary focus of these prior art attempts was to create a common data transmission protocol and communication interconnect adaptable for use within a single facility. It was thus thought that many vendors would adopt such a protocol by allowing them to maintain their proprietary control code structure, but allow the common protocol to transmit all code information to a central point for management.

[0008] U.S. Patent No. 4,939,728, owned by Echelon Systems Corp., describes a local area network (LAN) capable of communicating information through the existing power wiring of a single facility, given that the facility falls within certain size parameters and limitations. Data communication is effected through a standard protocol to transmit data to a central console, and, to the extent that the standard protocol was hosted by all of the brands of equipment comprising the facility, more than one type of equipment from more than one manufacturer could be managed through the central console. In practice, however, the common transmission protocol was provided without defining a common central management interface. Few manufacturers would acquiesce to the control rules for their equipment being devised and defined in accordance with another manufacturer's desires. In addition, though able to provide a rudimentary degree of multi-task and multi-vendor management, the '728 system was not able to manage geographically diverse or remote facilities, even those located on a common campus, because of the requirement that information be communicated through an existing power line network.

[0009] A further prior art attempt at multi-task and multi-vendor facilities management was described in U.S. Patent No. 5,684,826, owned by Acex, which provided an RS-485 serial communication modem which converts data for transmission over a power line network. Because a number of existing facilities products use RS-485 communication protocols, certain manufacturers were able to keep their existing code and protocol and capture the ability to transmit data in a LAN environment within a single facility. Although this prior art approach offers a rudimentary multi-task and multi-vendor capability with regard to equipment hosting the RS-485 communications protocol, it is disadvantageous in that while

rotation of the disk. All of the computing elements of the monitor system are contained within the utility watt-hour meter housing, and even the glass cover is replaced with a polycarbonate cover. Other similar devices installed within the existing meter housing are disclosed in U.S. Pat. No. 4,327,3625 and U.S. Pat. No. 5,506,404. A significant
5 disadvantage typical of these devices is that the installation process requires the existing meter to be physically opened and/or the optical light sensing arrangement to be assembled with professional assistance. Thus, an ordinary consumer generally cannot set up the device, and therefore consumers would have to bear installation costs.

In U.S. Pat No. 5,880,464, infrared light sensors are used to detect the shadow of
10 a meter pointer against a meter face to enable the meter reader to determine consumption rates. This automatic meter reader device is placed on the cover of the watt-hour meter. However, the device requires the angle and heights of the light source and sensor to be adjusted in a specific manner using a height adjustment carrier having a collar that must be tightened, which a typical customer most likely would find difficult to accurately
15 adjust. Furthermore, no provision is made for powering the device and thus further installation problems may be created for the consumer.

There are also certain utility-based applications in which a network controller or some other headend device located in a utility company interrogates the automatic meter reading device, in order to find out the utility usage for billing purposes. Typical
20 drawbacks that are inherent in these systems are that customers cannot see their use in real-time, cannot access this information except when a billing statement is received and, cannot see data except in the standard format chosen by the utility company.

In addition, there are various types of readers that can be utilized to manage the consumption of electrical power or fossil fuels. U.S. Pat. No. 6,167,389 allows the consumer, through the use of adapted end-use devices, to program these devices based on a pricing-tier billing system. The pricing-tier billing system sets a billing rate for power consumption based on the load levels on a power grid. A utility company may use a billing system with four-tiers: Normal Load, Medium Load, High Load, and Critical Load. Each tier has a different billing rate for power consumption with the Critical Load tier charging at the highest rate. The utility company may transmit data packets through an open network from a centralized headend to gateways at customer locations. These data packets cause the gateways to generate random startup time offsets, to control when end-use devices will be started. This is useful to protect the power grid from being loaded such that results in a blackout. However, this system does little to provide feedback to the consumer, let alone provide them with real-time data on their use and cost that allows the consumer to directly shed load voluntarily or with incentive, in order to help the utility balance its load demands. Thus, this device allows the utility company to obtain meter readouts are obtained for internal load and billing purposes only.

Summary of the Invention

The present invention provides an electro-optical, automatic meter reader (AMR) for enabling a consumer to view and manage power consumption on the consumer's computer, which may be a computer or PDA. The automatic meter reader is an apparatus for optically reading a meter using a sensor that can be used to monitor electricity consumption. A sensor of the apparatus may be attached to a bracket, which

may be mounted to the outside cover of the meter. An installation process of the apparatus need not require modification of the existing meter nor require removal of the housing of the existing meter. An end-user may install the automatic meter reader without special skills or tools, in fact, with no additional hardware other than those
5 included as a part of the system.

The photoelectric sensor beams a light onto a rotating disk, visible on the face of the meter, whose surface reflects the light. A marker such as a black dot or line placed on the rotating disk absorbs the beamed light resulting in an interval where a lower level of light is being reflected. The photoelectric sensor counts these intervals, representing
10 the number of turns the disk rotates indicating utility usage during a given time period. The apparatus connects to a data-collection unit through a first serial port. The data-collection unit stores the data from the sensor. The serial port connection may also serve to supply power for the apparatus through one otherwise unused pin of that serial
connector being assigned as a power carrier, thus avoiding the need for a dedicated power
15 supply. The data collection unit may also be used to store data when the computer is turned off and can be powered by an external 12 volt DC power supply.

The data-collection unit connects through a second serial port, located on the opposite side from the first serial port, to the user's computer. The computer provides the consumer with a centralized location to either directly or remotely view and manage his
20 power consumption. The software collects the data and provides the end-user with information relating to power consumption such as real-time rate of usage and historical usage levels. For example, information is arranged in three graphs that are analogous to information common to automobile travel. These include the real-time rate-of-use,

comparable to the speedometer of an automobile. This graph tells the user how much power they are consuming at this moment. The second graph, a monthly data graph displaying daily data, is comparable to the trip odometer. This graph shows the user how much power they have consumed on a day-to-date, daily and month-to-date basis. The

5 final graph is comparable to the general odometer. It shows the total energy consumption through the life of the system. Each graph can be displayed in units of kilowatt hours or dollars or other forms of currency. By presenting this data in three logical and understandable formats, data can be used to forecast whether the consumer will be under his monthly baseline utility usage or cost level of consumption based on then-current

10 requirements. Such forecasts are commonly used by trip computers in automobiles to tell the consumer whether they should adjust their speed to reduce fuel consumption, when they will arrive at their destination based upon present and average speed, and how many miles they have to go to complete their trip. If the power forecast indicates that the present usage will cause that consumer to exceed the baseline unit or cost level, the

15 consumer may control the power usage of end-use devices from the computer to assure that they end the time below this requirement, especially during power crisis situations. A forecast rate for use is shown for the consumer as a red colored line on each graph. A second line, the rate of consumption that must be averaged in order to arrive at or under the base line, is also displayed on each graph. If a consumer is averaging under their

20 baseline amount, for the period in question, the bar for that particular graph shall show as a green bar. If the consumer is averaging over the baseline amount for the period in question, the bar for that particular graph shall show as a red bar. For example, if the consumer is averaging a rate of consumption use on a daily basis that will exceed the

monthly baseline level if continued for the rest of the cycle, the monthly bar shall show as red. If the consumer is averaging a rate of consumption on an hourly basis that will exceed the average daily baseline, that day's bar shall show as red in color. In this way the consumer is always aware of their status to achieve baseline levels for the hour, day, and month.

Further, the consumer may program the computer to automatically control the rate of power consumption. Through commonly available products that accept commands to control thermostats, lighting and other household items, consumer may alert such products through automatic commands to adjust the thermostat on his air conditioning unit from his computer or program the computer to automatically adjust the temperature setting on the thermostat in response to the forecast. In addition, a communication system, such as the Internet, can also be utilized to allow the computer to communicate to the utility company for billing purposes or to allow the consumer to access and manage his power consumption from a remote computer or PDA.

Brief Description of the Drawings

The present invention will now be described in more detail with reference to preferred embodiments of the invention, given only by way of example and illustrated in the accompanying drawings in which:

Figure 1 illustrates a block schematic diagram of an apparatus for reading and managing power consumption in accordance with the present invention;

Figure 2A provides an illustrated embodiment of the reader in a plan view;

Figure 2B provides an illustrated embodiment of the reader in a side sectional view;

Figure 3A depict the bracket attached to a conventional meter in a front view;

Figure 3B depict the bracket attached to a conventional meter in a side view;

5 Figure 4 is an illustration of a preferred sensor;

Figure 5 provides an illustration of conventional utility meters;

Figure 6 illustrates a user interface displayed on the screen of the computer;

Figure 7 is an illustration of the computer connected to power consuming device through a serial port or Ethernet interface of the computer; and

10 Figure 8 provides an illustration of the computer connected to a communication system for remote access to the data stored and compiled on the computer.

Figure 9 illustrates an alternative embodiment of the present invention using wireless communication to transmit the data obtained by the reader.

Detailed Description

15 Figure 1 illustrates a block schematic diagram of an apparatus 100 for reading and managing power consumption in accordance with the present invention. As shown in Figure 1, a reader 104 is attached to a typical utility meter 102 such as an analog or digital power meter commonly found on homes, apartment buildings and commercial buildings. The reader 104 provides a means for automatically reading power
20 consumption and may eliminate the need for manually reading the meter 102. The data generated by the reader 104 may be continuously transferred through a connection such as a serial cable 120, to a data collection unit 106 or alternatively directly to the monitoring device 110, such as a computer.

The data collector **106** is therefore optional. When provided, the data collection unit stores data generated by the reader **104**. The data collection unit **106** may store data for a limited time when the monitoring device (computer) **110** is shut off or in the event of a power failure. With appropriate memory, the unit **106** may be able to store data for up to a year. The preferred embodiment of the data-collection unit **106** for a household may include a single serial port interface from the reader **104**, such as a RJ-11 or RJ-45 and a single serial port out, to the computer **110**, such as a DB-9. The preferred data-collection unit **106** is approximately 2" wide and 3" long and includes a 12 volt input, such as from a wall mounted AC to DC converter **108**. A battery, such as a standard watch battery, may be provided for backup. Further, the data collection unit **106** may be powered by the serial driver of one pin on the serial port of the computer. The preferred data-collection unit **106** includes a microprocessor such as a PIK Microprocessor including non-volatile memory and a timer crystal. It will be apparent that any microprocessor or controller could be used.

In a preferred application of the invention where multiple power meters are monitored, such as an apartment building or a commercial building, may be similar to the household application described above. However, the data collection unit **106** may be provided with inputs for additional readers **104**, such as four to eight inputs and an optional Ethernet connector for networking to a single monitoring device **110**.

The preferred embodiment of the monitoring device **110** may be a conventional general-purpose computer system or a serial server containing one or more serial ports and an Ethernet port, and need not be specific to this application. The monitoring device **110** receives the data from a cable **118**, such a serial cable, which connects directly to the

reader 104. Alternatively, a cable 116 may be a serial cable connecting to the optional data-collection unit 106 through a serial port in, such as a RJ-45 or RJ-11 connector and a serial port out, such as a DB-9 connector. The monitoring device 110 will not lose information during power failure as it stored its data in non-volatile memory and real-time data is only gathered when power is present and being consumed. In addition, when employed, the data collector 106 will not lose its data during an outage because it holds historic values in non-volatile memory and real-time data is only gathered when power is present and, thus, being consumed.

The monitoring device 110 may be connected to a communication system 112 or network, such as the Internet to allow remote access 114 of the data. For example, a utility company may obtain the data for billing purposes or by the end-user who wants to control his power consumption from his PDA or computer from a remote location, such as his office.

Figures 2A and 2B provides an illustrated embodiment of the reader 104 in both a plan view (Figure 2A) and a side sectional view (Figure 2B). The reader 104 includes a bracket 202 and a sensor 210 such as a photoelectric sensor. The bracket 202 preferably is a unitary body and lacks movable parts thus being relatively cost effective and also being easy to install. The preferred material for the bracket 202 is either rubber or plastic but it may be made out of any suitable material. Included in the bracket 202 may be an aperture 208 for accepting the sensor 210. The sensor 210 may be threaded into a nut 216 attached to the meter 102. For example, the nut 216 may be plastic and secured using glue or epoxy to the meter face. The nut 216 may fit into a recessed portion 218 of the bracket 202. In addition, a heat and moisture dissipation channel 212 may be

included to allow ventilation of the heat generated by the sensor **210**. The heat generated from the sensor **210** may be used to melt ice in cold-weather climates in which case melted ice may escape through the channel **212**. In addition, the channel **212** acts as a temperature equalization path between the sensor **210** and the outside elements, thus preventing the fogging of the lens in the sensor aperture **406**. The bracket **202** may also incorporate a fastener **204** and **206**, for example a hook and loop such as Velcro or double-sided tape or other adhesive to attach to the meter **102**. As illustrated in figure **2B**, the back of the bracket **202** may follow the same contour as the meter **102** to ensure proper alignment and secure mounting to the meter.

Figures **3A** and **3B** depict the bracket **202** attached to a conventional meter **102** in both a front view (Figure **3A**) and also a side view (Figure **3B**). The bracket **202** may attach to the translucent (typically glass), outside cover **306** of the meter **102** conventional to most existing electric utility meters. As mentioned above, the shape **214** of the bracket **202** may follow the same contour as the translucent outside cover **306** of the existing meter **102** ensuring proper alignment with the existing meter **102**. An installation process of the bracket **202** to the translucent outside cover **306** of the existing meter **102** need not require modification of the existing meter **102** nor removal of the translucent outside cover **306**. Furthermore, the installation may only require one part of the bracket **202** to be rigidly attached to the translucent outside cover **306** allowing an end-user to install the reader **102** without special skills or tools.

Figure **4** is an illustration of a preferred sensor. The reader **104**, in a preferred embodiment, utilizes a photoelectric sensor **210** such as the Mini-Beam 2 from the Banner Engineering Corp. of Minneapolis, MN to read the existing meter. The sensor

210 includes a light source and a photo receptive element. The preferred size of the sensor 210 is about a 1" square but is not limited to that size. The preferred sensor also includes a threaded member 406 which may be screwed into a nut 216 secured to the meter housing 306 as mentioned above. The nut 218 may also secure the sensor 210 to the bracket 202 as shown in Figure 2B. For example, the nut 216 may fit into a recessed portion 218 of the bracket 202. A light emitting diode (LED) 402 may be placed on the back of the sensor 210 to provide a visual indication that the sensor 210 is picking up the correct signal such as to aid in installation of the reader 104. The sensor 210 may incorporate a cable 404, such as a serial cable, that supplies the power preferably with 10V or 12 V but may range from 10 – 30V. The cable 404 may also provide the means for transferring data.

Figure 5 provides an illustration of conventional utility meters 102 such as a digital meter 506 and an analog meter 508. The sensor 210 (Figure 4) is oriented to beam a light, such as a visible red 660 nm, or another wavelength, onto a rotating disk 502 located in the meter 102. The beam of light passes through the translucent outside cover 306 of the meter 102. The surface of the disk 502 reflects the light; the reflected light is sensed by the photo receptive element of the sensor 210. A marker 504, such as a darkened area, normally found on the rotating disk 502 absorbs the beamed light resulting in an interval where a lower level of light is being reflected to the sensor 210. The number of intervals, counted by the sensor 210, represents the number of turns the disk rotates indicating utility usage during a given time period. The time between each interval is inversely proportional to the rate of power consumed. Further, the aforementioned LED 402 may turn on to indicate whether the sensor 210 has made contact with the

rotating disk 502 and turn off when the black marker 504 is being sensed, thus a consumer with no special skills, will be sure of the proper alignment of the sensor 210.

The reader 104 may use software algorithms to avoid spurious data in which light sensors are vulnerable to such as may be caused by sunlight striking the rotating disk 502.

5 The rotating disk 502 in a meter 102, may have a maximum number of rotations per second and the reader 104 may be programmed to ignore certain detections. For example, if a sensor detects more than 2 passes per second from a rotating disk 502 with a 2 rotations per second maximum, the reader 104 may be programmed to ignore the second pass. The reader 104 also may have the capability to alert the end user that an
10 adjustment may need to be made to the sensor 210.

The reader 210 may also use a software algorithm that avoids spurious data based on the time interval between each pass. For example, if a long-short-long pattern of the intervals between passes is sensed by the reader 210 may be programmed to ignore the middle short reading. Again, an alert signal may be sent to the end user that an
15 adjustment may need to be made to the sensor 210.

Figure 6 illustrates a user interface displayed on the screen of the computer 110 (Figure 1). As Illustrated in Figure 6, the computer 110 may provide a central location for the end-user to remotely connect to or use directly to view the data collected by the reader 104. Software stored in the computer 110 memory causes the computer 110 to
20 compile counted intervals from the reader. The software may be compliant to all automatic meter reading devices, and therefore might not be specific to the aforementioned reader 104. In addition, the software may incorporate an adjustable architecture to optimize for various sizes and complexities fitting to the end-user's need.

An interface 602 such as web-based interface (e.g. a browser), allows the end-user to monitor the information relating to power consumption. The interface 602 may, for example, render all graphic data as line or bar graphs 608 using Macromedia Corporation's Flash program. By choosing to render data via flash, the vast majority of the program overhead for rendering the interface 602 is handled directly in the browser of the computer used to display the interface 602. Thus, the computer 110 may be an inexpensive device such as a serial server or other device which contains one or more serial ports. Because an end user might want to view monthly bar graphs 608 of power consumption, Macromedia Flash provides the ability to present real-time moving graphs or pictures. This might be utilized when providing real-time power consumption rate 606 such as a line graph or chart depicting power usage over time or up-to-date/cost per billing cycle costs. In addition the interface 602 may be provide other data such as peak demand rate including date and time of the peak demand. The interface 602 is structured in automobile-familiar methods for ease of use and so that an end-user need not require special training or skills to use.

Illustrated in Figure 7 are devices 702 such as Heating Ventilation Air Condition (HVAC) systems and other power consuming devices that may be connected to the computer 110 through a serial port or Ethernet interface of the computer 110. The interface 602 may provide the end-user with information on what devices are being currently used, the rate of power consumption the device operates at, and the ability to control these devices based on measured consumption. Therefore, allowing the end-user to manage the rate of consumption for that household.

The ability to manage the rate of consumption may be especially advantageous when dealing with utility companies that use a penalty-level billing system. In this system, if a customer exceeds a predetermined level of power consumption or baseline level, then the utility company may charge a premium rate for the power consumed above the baseline. Some utility companies may also provide rebates on future bills when a customer falls below a predetermined level of usage for a given period. The interface 602 may provide a forecast based on a real-time rate of consumption to determine whether the end-user will be under his monthly baseline utility usage level of consumption or other predetermined level. The forecast may be computed by taking the average power consumption used per day of the current billing cycle and multiplying it by the number of days in a billing cycle. So, for example, if the customer was on day 5, the forecast will divide the total power usage at that time by 5 to compute a daily average and then multiply the daily average by the number of days in the billing cycle. A new forecast may be computed continuously based upon present and historical usage. If the forecast indicates that the usage will exceed the baseline level the consumer may control the power usage of end-use devices from the computer 110 to fall below this requirement, especially during power crisis situations. For example, the end-user may turn off unnecessary lights or decrease the length of time certain devices will run such as a dryer or a HVAC system from the computer 110.

Further, the consumer may program the computer 110 to automatically manage the rate of power consumption. For example, if the forecast is indicating that the consumer will exceed the baseline level if continued for the entire billing cycle, the end-user might program the computer 110 to automatically raise or lower the temperature on

the thermostat a few degrees. This may provide the end-user with the consumption rate of each device and plan use of certain devices accordingly. This may be useful in setting up exact budgets and strictly adhering to them in an automated manner using the computer 110.

5 In addition to avoid being charged a premium rate for power consumption, the forecast can allow the end user to fully utilize all of the non-premium power allocated to him. For example, rather than shutting off the HVAC system and enduring an uncomfortable climate, the end user can use the forecast to determine a adjust the thermostat at a certain temperature the forecast may allow the end user to adjust the
10 temperature so that he can stay under the baseline and yet enjoy in a comfortable temperature.

 Using the interface 602 provided by the software stored on the computer 110, the end-user may also determine an optimization schedule for running the devices 702. The end-user may obtain data such as cost per hour device used or cost/cycle (washing
15 machine). This may help determine whether the device is properly running as efficient as intended by the manufacturer. Also based on this information, the end-user may program or choose from created device-operating schedules to maximize cost effectiveness and power conservation.

 In addition to monitoring and controlling of power-consuming devices, the
20 monitoring device 110 may perform other control functions. For example home security systems and fire alarm systems may be connected. The end-user may control these devices through the interface and program the monitoring device to treat to signals sent by these systems.

Illustrated in Figure 8, the computer 110 may be connected to a communication system 804, such as the Internet. This may allow remote access to the data stored and compiled on the computer 110. By allowing remote access to the data on the computer 110, the end-user may control power consuming devices and other devices from any location such as a computer at work 808 or from his PDA 810. For example, the end-user may want to raise or lower the temperature of his house before coming home.

There may be situations when the end-user wants to make sure that no power is being consumed, when the end-user is on vacation or business trip or when a house or baby sitter is at the premises, for instance. Remote access to power consumption information may provide the end-user with information on whether power is being consumed, at what rate it is being consumed, what device is consuming the power and the ability to control that device.

The utility company 806 may also communicate with the computer 110 to obtain the data for billing purposes. The utility company 806 may download the monthly power consumption information from the Internet and bill the end-user accordingly. In addition the utility company 806 may set up an on-line billing service and thus cut down on costs incurred in mailing the bill. Further, this may allow utility company 806 to forecast when more power is going to be consumed each day and to send emergency alerts to households or apartment/office buildings to control the power usage during a crisis situation.

Remote access to the data may provide landlords of apartment/commercial buildings with readily available utility cost information. Landlords can provide potential lessees current and historic monthly averages of utility bills from their

PDA/computer/laptop 814. Also, landlords live in locations far from the property they own, possibly in a different state. Also the landlord may use the data to determine at what rate each tenant is consuming power and can adjust their rent or utility charges accordingly.

5 By having remote access to control power-consuming devices, the landlord or utility company might regulate the rate of power consumption while not physically going there. For example, the landlord may control the temperature of the common area of the building from his home computer 814 or even programming the lights to turn off at certain times during the day when sunlight is adequate. The utility company 806 may
10 turn off certain devices such as HVAC systems when the power-grid is approaching maximum capacity.

Figure 9 illustrates an alternative embodiment of the present invention. Unless specifically stated, all elements, of Figure 9 have a one-to-one functional correspondence with those of Figure 1. Figure 9 differs from Figure 1 in that the serial cable 120 (from
15 Figure 1) that connects the reader 104 and the data-collection unit 106 is replaced with a wireless communication channel. A transmitter 906 for sending wireless communications may be attached to the reader 104 using a shorter serial cable. A receiver 908 may be attached via another shorter serial cable to the data-collection unit 106 for accepting the transmitted communications from the transmitter 906. The
20 transmitter 906 may send data via a wireless carrier frequency, such as 433 MHz, which is standard for garage door openers. It will be apparent, however that another frequency (e.g., 900 MHz) could be used. The signals sent via the transmitter 906, may be in the format of pulses that are created directly from the intervals of lower levels of reflected

light sensed by the sensor 210. Thus, each pulse formed by the reader may result in a pulse at the carrier frequency communicated by the transmitter 906. To communicate the pulse to the data-collection unit 106, the transmitter 906 may send a burst of the carrier frequency to represent each revolution of the rotating disk 502. The wireless signal from the transmitter 906 may be encoded with identification information placed on the carrier frequency to prevent interference from other sources. It will be apparent that a number of different schemes may be used for communicating the revolution of the rotating disk 502 via the transmitter 906 and receiver 908. The transmitter 906 and the receiver 908 may receive operating power from a battery or a wall-mounted AC to DC converter.

10 Similarly to the embodiment of Figure 1, the reader 104 may communicate directly with the computer 110. In which case, the receiver and cable 904 may be mounted to the computer 110 rather than the data collection unit 106. In addition, the data collection unit 106 may be omitted.

Wireless communication may be used to help eliminate routing problems when using serial cables such as length of the cable needed and outdoor to indoor routing. The wireless communication device would also be helpful for small businesses in which there are multiple readers which all have to be connected to a monitoring device 110.

While the foregoing has been with reference to particular embodiments of the invention, it will be appreciated by those skilled in the art that changes in these embodiments may be made without departing from the principles and spirit of the invention, the scope of which is defined by the appended claims.

What is claimed is:

- 1 1. An apparatus for reading electric power consumption, comprising:
2 an optical sensor for sensing indicia of electricity consumption from an
3 electric utility meter;
4 a bracket having unitary body for positioning the optical sensor with
5 respect to the electric utility meter, the sensor positioned externally to a
6 translucent cover of the electric utility meter; and
7 a means for mounting the bracket to the electric utility meter.
- 1 2. The apparatus according to claim 1, wherein the optical sensor senses rotation of a
2 disk located inside the translucent cover of the electric utility meter.
- 1 3. The apparatus according to claim 1, wherein the bracket lacks movable parts.
- 1 4. The apparatus according to claim 1, wherein the optical sensor obtains power for
2 operation of the optical sensor from a serial cable coupled to the optical sensor.
- 1 5. The apparatus according to claim 4, further comprising a data collector coupled to
2 the serial cable for collecting data related to electricity consumption.
- 1 6. The apparatus according to claim 1, wherein the data collector includes memory
2 for storing data related to electricity consumption.
- 1 7. The apparatus according to claim 6, wherein the data collector stores the data
2 despite a power failure.
- 1 8. An apparatus for reading electric power consumption, comprising:

2 an optical sensor for sensing indicia of electricity consumption from an
3 electric utility meter, wherein the optical sensor obtains power for operation of the
4 optical sensor from a serial cable coupled to the optical sensor;
5 a bracket for positioning the optical sensor with respect to the electric
6 utility meter, the sensor positioned externally to a translucent cover of the electric
7 utility meter; and
8 means for mounting the bracket to the electric utility meter.

1 9. The apparatus according to claim 8, wherein the optical sensor senses rotation of a
2 disk located inside the translucent cover of the electric utility meter.

1 10. The apparatus according to claim 8, wherein the bracket is unitary.

1 11. The apparatus according to claim 8, wherein the serial cable is coupled to a data
2 collector.

1 12. The apparatus according to claim 8, wherein the data collector includes memory
2 for storing data related to electricity consumption.

1 13. The apparatus according to claim 12, wherein the data collector stores the data
2 despite a power failure.

1 14. A system for monitoring and controlling power consumption comprising:
2 a reader for obtaining power consumption data from an electric utility
3 meter;
4 a computer system for collecting the data from the reader and for
5 controlling an amount of power consumption by controlling a device that
6 consumes electricity based on the data from the reader and the input from the
7 user; and
8 a user interface at the computer system for accepting input from the user.

1 15. The system according to claim 14, wherein the computer system computes a
2 forecast of electric power consumption for a predetermined period of time based on usage
3 for a portion of the predetermined time period.

1 16. The system according to claim 15, wherein the computer system repeatedly
2 computes the forecast.

1 17. The system according to claim 15, wherein the computer system controls the
2 device in response to the forecast.

1 18. The system according to claim 17, wherein the computer system controls the
2 device so that usage for the predetermined time period falls below a predetermined
3 amount.

1 19. The system according to claim 17, wherein the device includes a climate control
2 device.

1 20. The system according to claim 19, wherein the climate control device is an air
2 conditioning unit.

1 21. The system according to claim 18, wherein the predetermined amount represents a
2 baseline above which cost of the electricity increases.

1 22. The system according to claim 18, wherein the predetermined amount represents a
2 target and when usage falls below the target for the predetermined time period the user
3 becomes entitled to a rebate.

1 23. The system according to claim 14, wherein the user interface displays indicia
2 related to power consumption to the user.

- 1 24. The system according to claim 23, wherein the indicia related to power
2 consumption is representative of historical usage.
- 1 25. The system according to claim 23, wherein the indicia related to power
2 consumption is representative of then-current usage in real time.
- 1 26. The system according to claim 25, wherein the indicia related to power
2 consumption includes a moving picture.
- 1 27. The system according to claim 26, wherein the moving picture includes a chart of
2 usage.
- 1 28. The system according to claim 14, further comprising means for accessing the
2 user interface from a location remote from the computer system for providing the user
3 input.
- 1 29. The system according to claim 28, further comprising means for displaying
2 indicia related to power consumption at the remote location.
- 1 30. A method of monitoring and controlling power consumption comprising:
2 reading power consumption data from an electric utility meter using an
3 automatic reader;
4 collecting the data from the reader in a computer memory device;
5 computing a forecast of electric power consumption for a predetermined
6 period of time based on usage for a portion of the predetermined time period
7 using a computer system; and
8 controlling an amount of power consumption by the computer system
9 controlling a device that consumes electricity based on the forecast.
- 1 31. The method according to claim 30, wherein said controlling controls the device so
2 that usage for the predetermined time period falls below a predetermined amount.

1 32. The method according to claim 30, wherein the predetermined amount represents
2 a baseline above which cost of the electricity increases.

1 33. The method according to claim 30, wherein the predetermined amount represents
2 a target and when usage falls below the target for the predetermined time period the user
3 becomes entitled to a rebate.

1 34. The method according to claim 30, further comprising displaying indicia related
2 to power consumption.

1 35. The system according to claim 34, wherein the indicia related to power
2 consumption is representative of historical usage.

1 36. The system according to claim 34, wherein the indicia related to power
2 consumption is representative of then-current usage in real time.

1 37. The system according to claim 36, wherein the indicia related to power
2 consumption includes a moving picture.

1 38. The system according to claim 37, wherein the moving picture includes a chart of
2 usage.

1 39. A system for monitoring and controlling power consumption comprising:
2 a reader for obtaining power consumption data from an electric utility
3 meter;
4 a computer system for collecting the data from the reader and for avoiding
5 spurious data created by an external light; and
6 a user interface at the computer system for accepting input from the user.

1 40. The apparatus according to claim 39, wherein the system senses an occurrence of
2 more than two passes in one second.

1 41. The apparatus according to claim 40, wherein the system ignores a second one of
2 the two passes.

1 42. The apparatus according to claim 39, wherein the system senses a time interval
2 between each pass.

1 43. The apparatus according to claim 42, wherein the system ignores a middle one of
2 the intervals if a long-short-long pattern is sensed.

1 44. The apparatus according to claim 43, wherein the system ignores the middle short
2 reading if the long-short-long pattern is seen twice.

1 45. The apparatus according to claim 39, wherein in response to sensing the spurious
2 data, the system alerts an end user when an adjustment to the optical sensor is needed.

1 46. An apparatus for reading electric power consumption, comprising:
2 an optical sensor for sensing indicia of electricity consumption from an
3 electric utility meter;
4 a wireless transmitter coupled to the optical sensor for generating a signal
5 representative of the indicia of electricity consumption; and
6 a wireless receiver coupled to a data collector for receiving the signal from
7 the wireless transmitter.

1 47. The apparatus according to claim 46, wherein the optical sensor senses rotation of
2 a disk located inside the translucent cover of the electric utility meter.

1 48. The apparatus according to claim 47, wherein the signal includes indicia
2 representative of each revolution of the disk.

- 1 49. The apparatus according to claim 46, wherein the data collector is a general
2 purpose computer system.
- 1 50. The apparatus according to claim 46, wherein the data collector is coupled to a
2 general purpose computer system.
- 1 51. The apparatus according to claim 47, wherein the signal sent by the transmitter is
2 a pulsed carrier frequency with each pulse representing one revolution of the disk located
3 inside the electric utility meter.
- 1 52. The apparatus according to claim 46, wherein the signal sent by the transmitter is
2 encoded with source identification information.
- 1 53. The apparatus according to claim 46, wherein the transmitter sends the signal via
2 a 433 MHz carrier frequency.
- 1 54. The apparatus according to claim 54, wherein the data collector includes memory
2 for storing data related to electricity consumption.
- 1 55. The apparatus according to claim 54, wherein the data collector stores the data
2 despite a power failure.

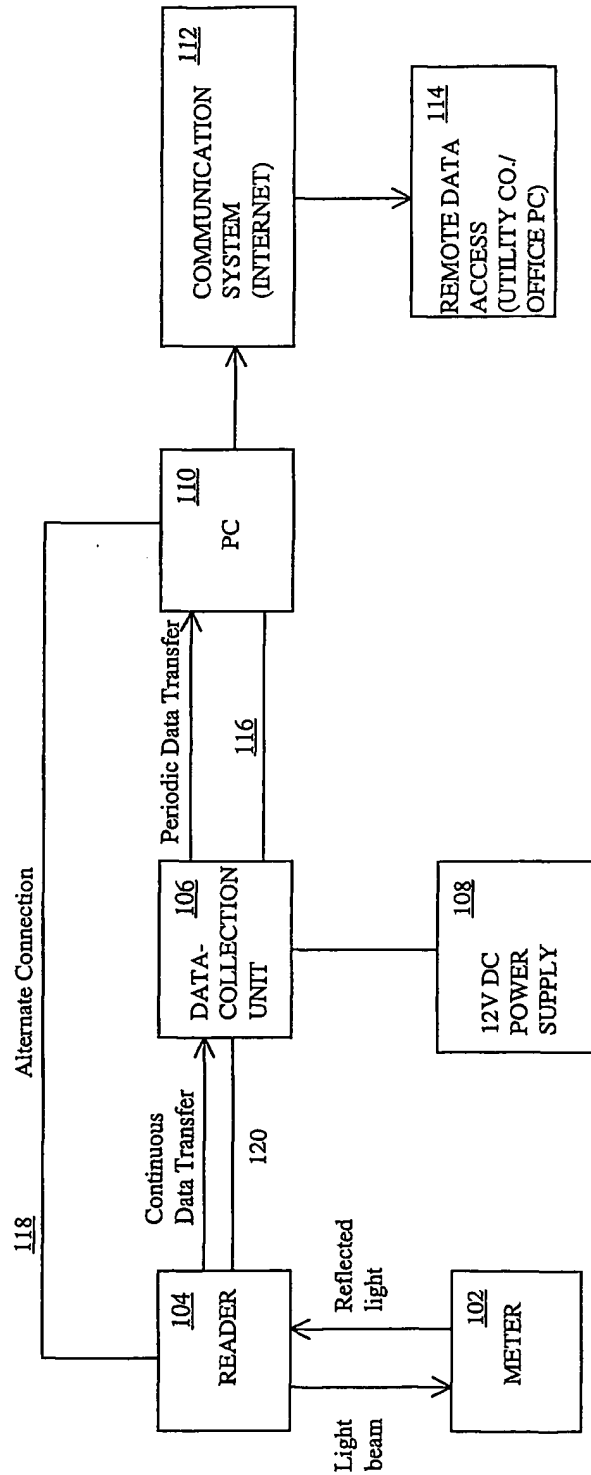


Figure 1

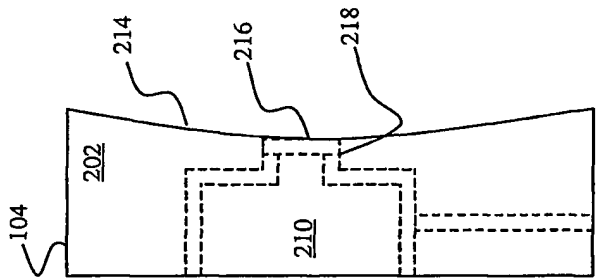


Figure 2B

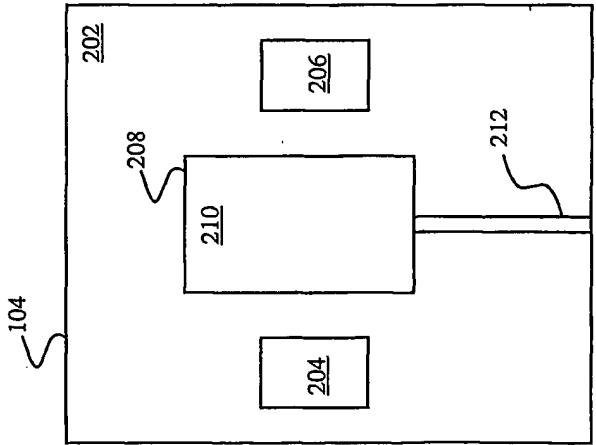


Figure 2A

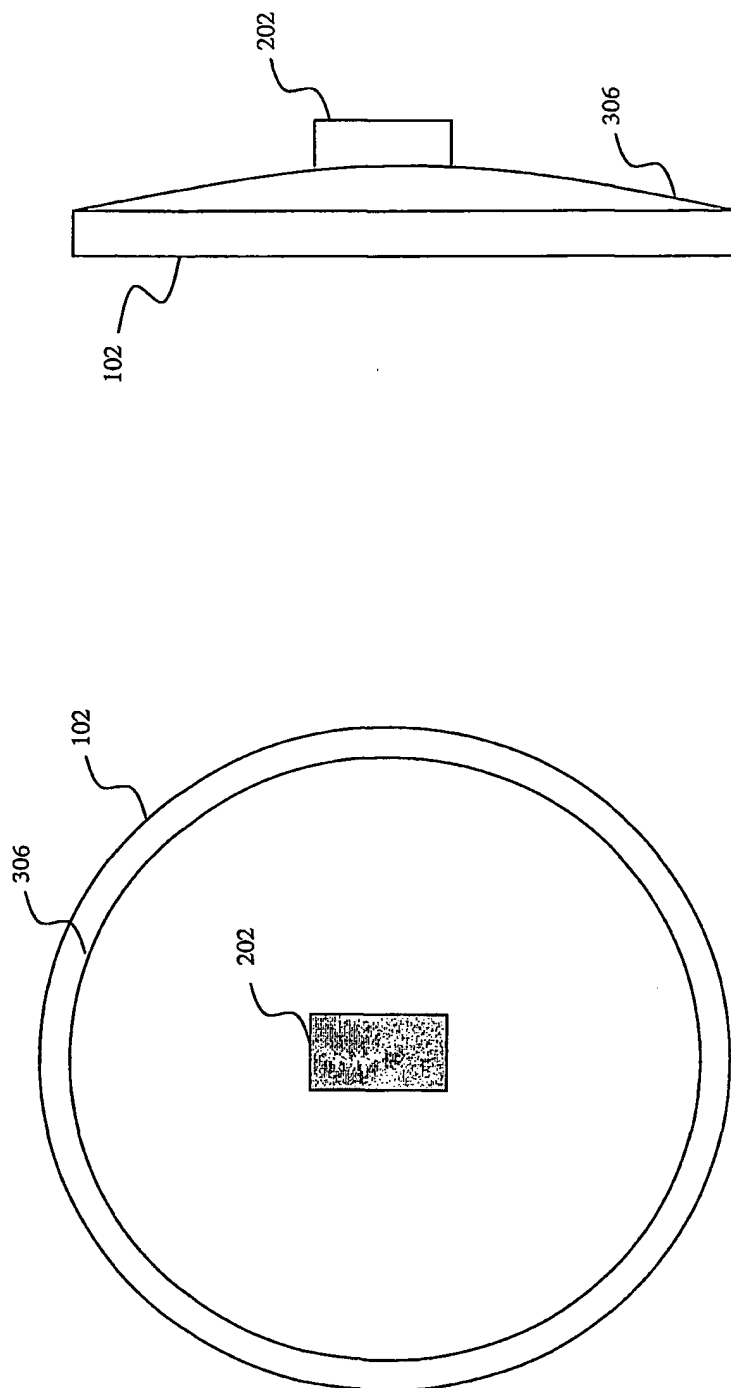


Figure 3B

Figure 3A

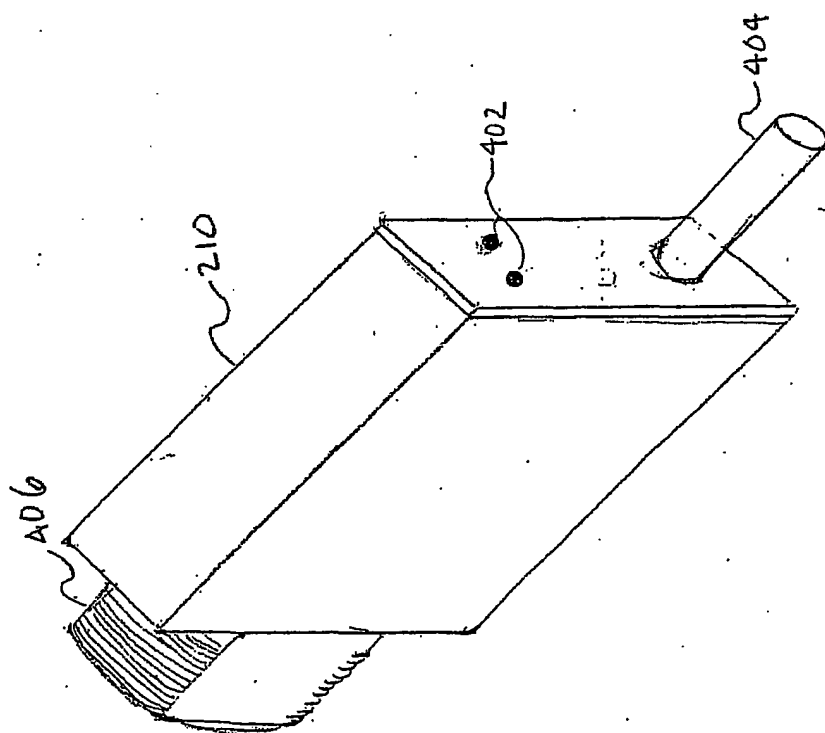


Figure 4

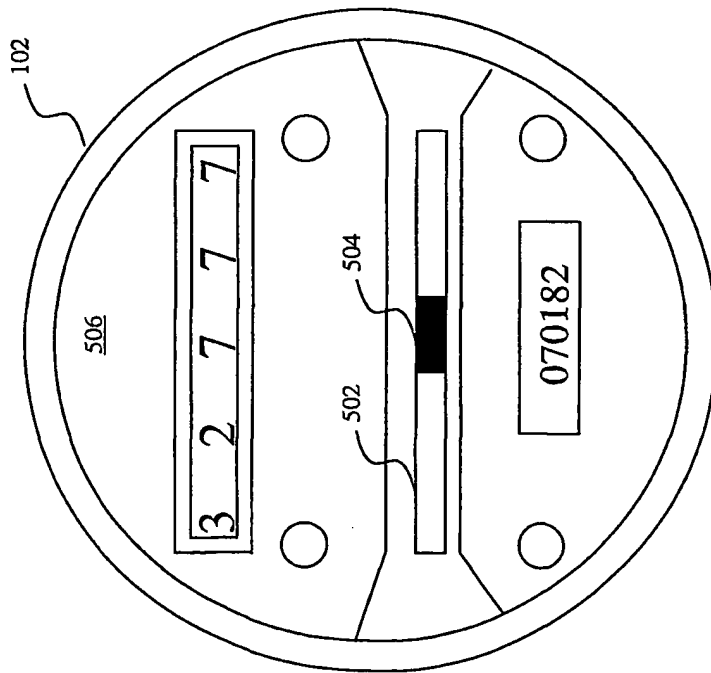
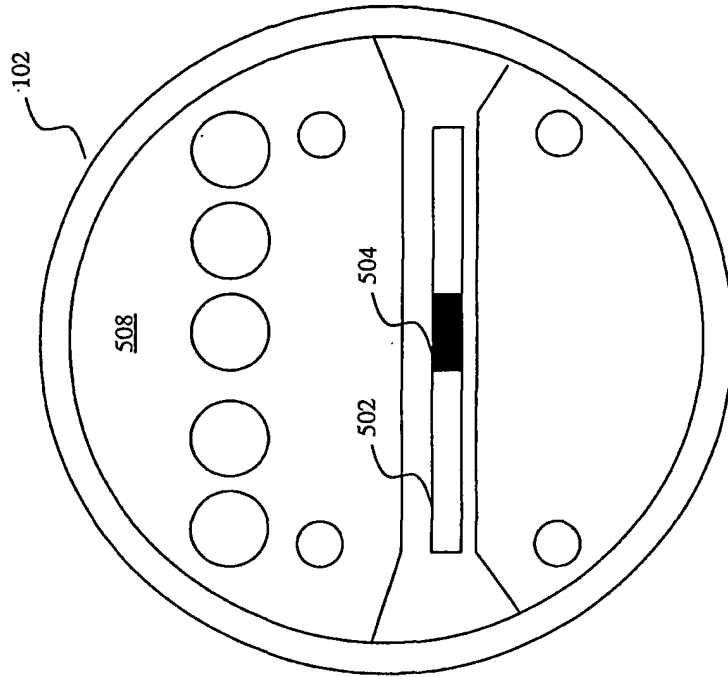


Figure 5

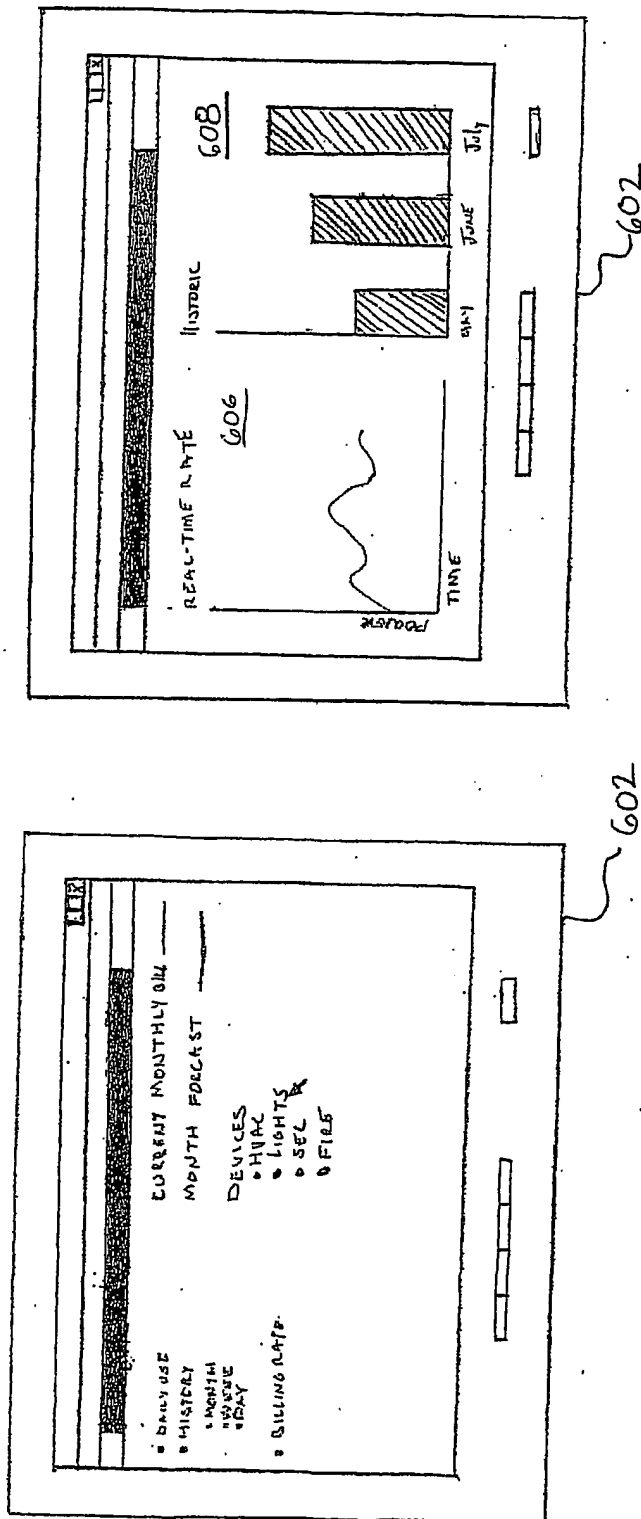


Figure 6

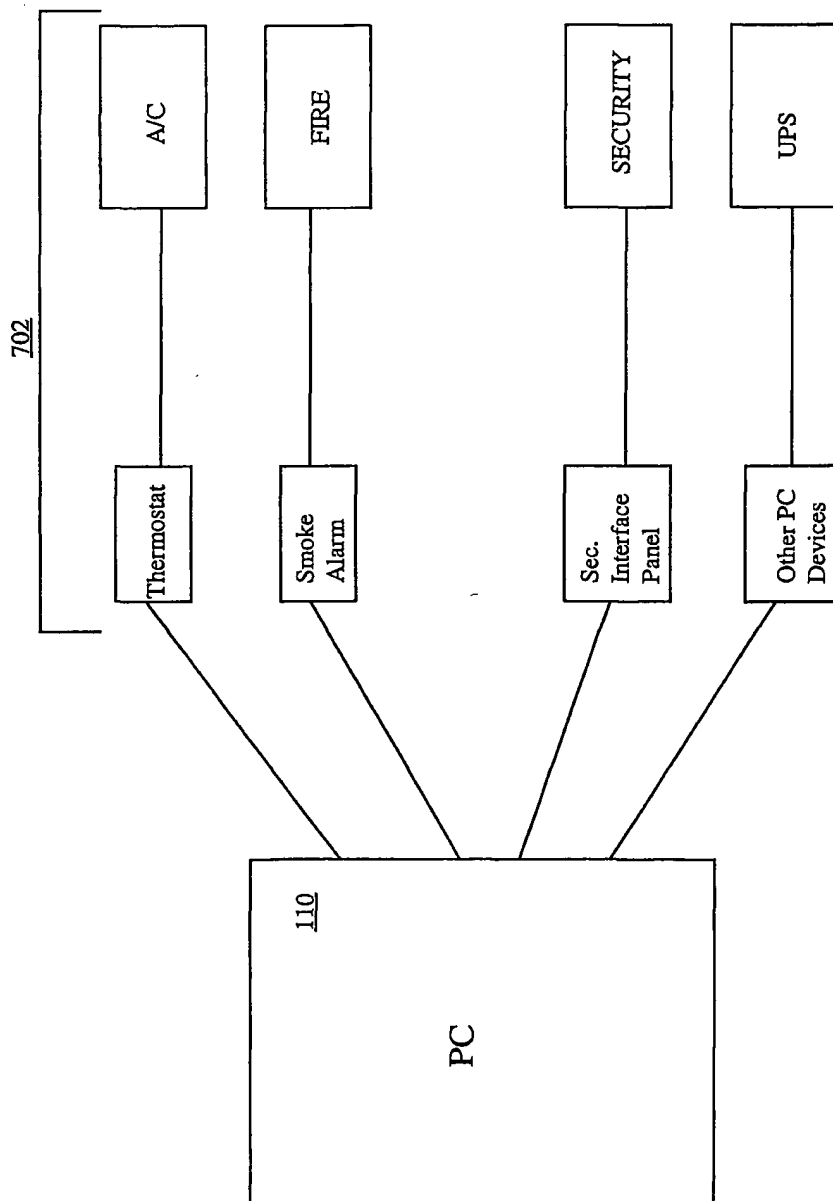


Figure 7

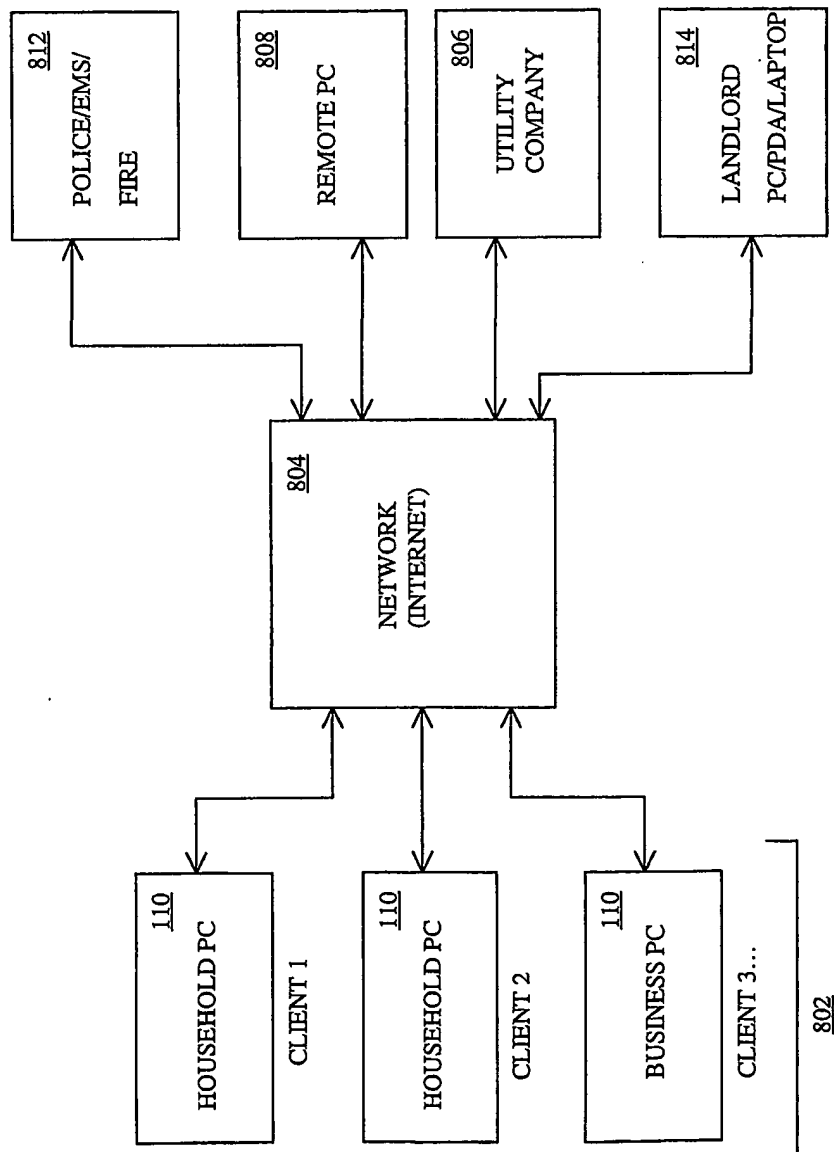


Figure 8

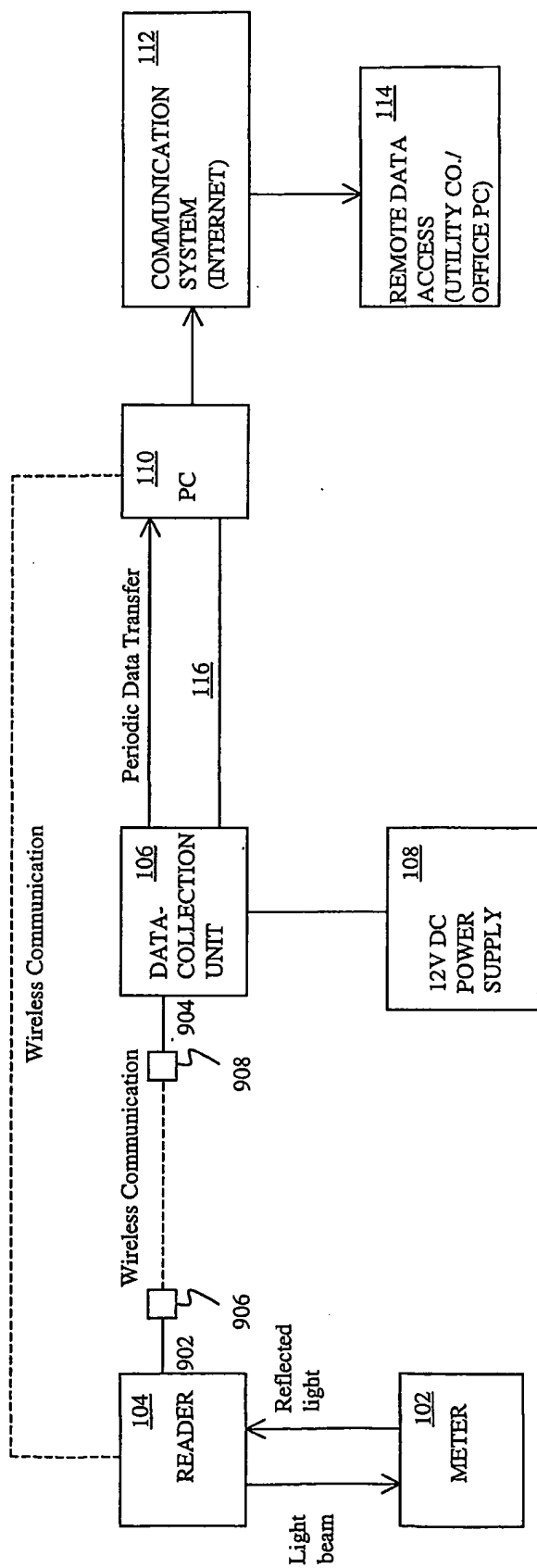


Figure 9